Radio emission in the virgo cluster and in so galaxies

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Chapter IV. Summary

A survey of the radio continuum emission from the galaxies in the Virgo Cluster is presented in Chapter II. The sample of 274 galaxies in total contains a subsample of 188 galaxies complete down to magnitude $m_p = 14$. The observations consisted mostly of short (10 minutes) observations providing one-dimensional (East-West) strip distributions of the radio brightness at 1.4 GHz, with an East-West resolution of 23" allowing separation of central sources from extended emission, and an r.m.s. noise level of 2 mJy.

Full-synthesis (two dimensional) maps were made of a few fields in the cluster. In the giant elliptical galaxy M49 (NGC4472) a double-lobed radio source was found for the first time, with a size of 5 kpc and a monochromatic luminosity $P_{1.4} = 2 \times 10^{21}$ W/Hz (paper 1). Radio galaxies had not been seen previously at such a low luminosity, which was thought to be more typical of radio emission in spirals. In NGC4438, a peculiar galaxy in the core of the cluster, the continuum radio emission and the neutral hydrogen are displaced above the disk of the galaxy by up to several kpc (paper 2), showing for the first time the process of ram-pressure stripping, which was predicted previously to occur in rich clusters, and which is thought to be responsible for the formation of SO galaxies out of spirals. The large radio halo of M87 (size 12'× 16') was mapped at a frequency of 0.6 GHz (paper 3). This map shows for the first time evidence that the halo is in fact a double lobed source.

The observation methods and the results of the survey are given in paper 4. The analysis of the survey is presented in section II.3. The radio luminosity function (RLF) is derived for the 133 brightest galaxies in the cluster ($-21 \leq M_B \leq -17$). A comparison with Hummel's RLF of nearby galaxies shows that the spirals in the Virgo cluster are weaker by a factor of 1.5 to 2. This difference is due to two selection effects: the Virgo sample contains a larger fraction of early-type galaxies and is more complete at faint optical magnitudes. The variation with distance from the cluster centre of the luminosity of the detected galaxies and of the sizes of the radio sources is also examined. The ratio of the radio luminosity to optical luminosity of spiral galaxies may increase towards the cluster centre. Three effects could be responsible: the deficiency of late-type spiral galaxies in the cluster centre, the higher rate of galaxy encounters in the cluster centre, and the interaction of spiral galaxies with the diffuse gaseous halo of M87. Four spiral galaxies in the cluster centre show radio disks smaller than usual, which could be an effect of ram-pressure sweeping.

The radio emission of SO galaxies is examined in Chapter III. In section 2, a sample of 145 SO galaxies is obtained by combining the Virgo cluster SO's with the nearby non-cluster SO's (paper 5). The radio data, mainly from short observations, are used to derive the RLF. The radio emission in SO galaxies is at least three times weaker than that in ellipticals and spirals. Flat-spectrum compact nuclear sources are found in SO galaxies but they are at least 10 times weaker than in elliptical galaxies, which is attributed to the small mass of the bulges in SO's as compared to the mass of elliptical galaxies. The absence of steep-spectrum, extended central sources and of disk radio emission in SO's is attributed to their low neutral hydrogen content.

The question of the presence of double-lobed radio sources in SO galaxies is examined in some detail in section 3. NGC 3665, a nearby SO galaxy with weak double-lobed emission, was mapped at frequencies of 0.6, 1.4 and 5 GHz (paper 6). Surface photometry shows no exponential disk in NGC 3665, which could hence be a misclassified elliptical galaxy. In the powerful radio galaxy NGC 612 an optical disk could be present (paper 7). A compilation of 8 radio galaxies with dust lanes shows that the radio axis tends to be perpendicular to the dust lane (paper 8). This correlation, combined with the morphology of the radio source, the shape of the dust lane and its orientation with respect to the optical isophotes, can be exploited to construct models of M84 and of Centaurus A as triaxial ellipsoids (section 4, paper 9).

The problem of the classification of SO galaxies is reviewed in section III.5. The distribution of axial ratios for SO radio galaxies indicates a population dominated by misclassified ellipticals. It is suggested that elliptical galaxies with dust lanes are essentially different from SO's. The conclusion is that the evidence for double-lobed emission in SO galaxies is weak at present. An enlarged sample of 14 radio galaxies with dust lanes shows that the radio axis tends to be perpendicular to the dust lane only for sources with monochromatic luminosity $P_{1.4} > 10^{24}$ W/Hz.